International Journal of Modern Physics E

Evolution of the Away-Side Jet Shapes in $\pi^0 - h^\pm$ Correlations in 200 GeV Au+Au Collisions with RHIC-PHENIX

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Received (received date)
Revised (revised date)

Two-particle azimuthal correlations have allowed detailed study of the modification to di-jets in the hot, dense medium created in RHIC collisions. Light can be shed by such correlations on many novel effects discovered at RHIC such as the enhanced p/π^+ ratio and conical structure of events with energy loss. Using π^0 triggers to reduce the effect of recombination we explore high-p_T correlations to explore the away-side structure.

1. Introduction

The studies of hard scattering processes in the heavy ion environment, previously uncharted before the advent of RHIC, have resulted in very dramatic results. Initial results, and the most cited, are the single particle studies where a suppressed production of high-p_T particles compared to binary-scaled $p+p$ collisions is observed [1]. Two-particle studies, via the azimuthal correlation between two high-p_T particles, have extended these single particle studies to infer properties of the jets themselves responsible for the particle production. At p_T of 2-5 GeV/c, where hard scattering production dominates in $p+p$ collisions, there are strong modifications to the structure of the two-particle correlations. In both the near-side and away-side the jets show yields which are enhanced compared to $p+p$ at low-$p_{T,assoc}$ and suppressed at the highest $p_{T,assoc}$ [2]. The shape of the away-side correlations at these intermediate p_T are also broader and show a humped structure compared to those in $p+p$ collisions [3]. Another difference in particle production between $p+p$ and $Au+Au$ at these p_T is the observation of enhanced baryon production. The p/π^+ ratio is a factor of ∼5 larger than that measured in $p+p$ [5]. These ratios and spectra are consistent with models of recombination of partons from the medium and partons from jet fragments [4]. In fact, recent results indicate that the structure of the away-side seems to be dependent on the flavor of the associated particle [6].

*For the full list of PHENIX authors and acknowledgements, see Appendix 'Collaborations' of this volume

This contribution focuses on $\pi^0-h^\pm$ correlations at high trigger p_T (>5 GeV/c). This is motivated for several reasons. First, given a high-p_T π^0, the effects on these correlations from recombination is small [7] and less than the effects from using an unidentified hadron trigger. Next, it is instructive to measure the away-side structure of these correlations at high-p_T to determine if the structure is similar to the lobed structure observed in lower-p_T correlations. Finally, since the away-side parton on average travels through a longer medium path length, effects of energy loss should be more evident on the away-side. Whatever away-side structure exists, it is important to measure the yield and shape to quantify this modification compared to $p+p$.

2. High-p_T Azimuthal Correlations

Azimuthal correlations are a well-established tool to measure jet fragments in all RHIC collisions. Details of the method used to measure correlations are found in reference [8]. Briefly, azimuthal correlations are measured in all events with a trigger particle. Detector acceptance and efficiency correlations are measured by correlating particles from different events. These are then removed from the real pair correlations to reveal the physical correlations.

The π^0 trigger particles are measured in PHENIX by their $\gamma\gamma$ decay channel in the electromagnetic calorimeter. One feature of using π^0 triggers is there are fake triggers from combinatoric photons under the π^0 mass peak. One experimental advantage of using π^0 triggers is the ability to measure the signal-to-background (S/B) in the triggers and to measure the correlations due to these fake π^0 triggers. Example di-photon invariant mass peaks are shown in Fig. 1 for 0-20% Au+Au

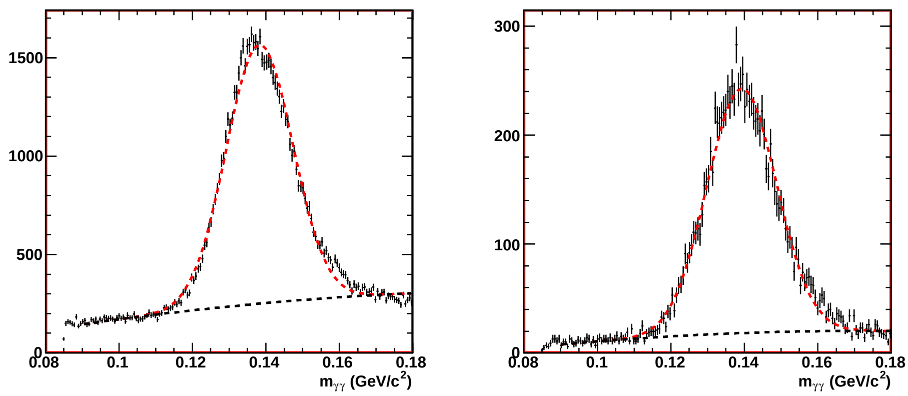

Fig. 1. Di-photon invariant mass distributions for 0-20% Au+Au collisions and photon pair p_T from 5-7 GeV/c (left) and 7-20 GeV/c (right). Dashed line is a Gaussian and polynomial fit to describe the signal and background.

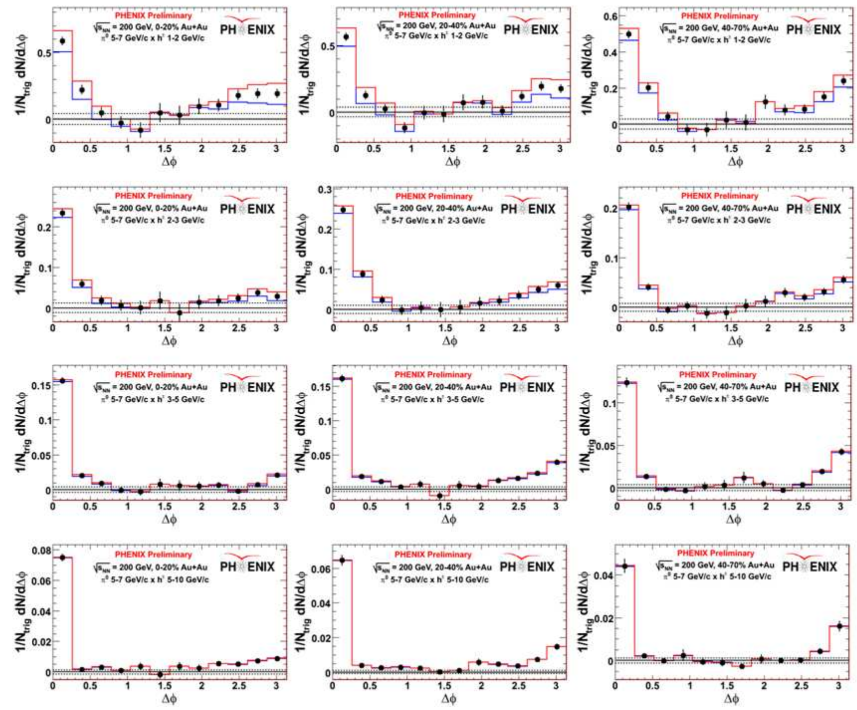

Fig. 2. Correlations between π^0 triggers from 5-7 GeV/c and associated hadrons from 1-2 GeV/c (upper row), 2-3 GeV/c (second row), 3-5 GeV/c (third row), and 5-10 GeV/c (lower row) in Au+Au collisions in 0-20% central (left column), 20-40% central (middle column), and 40-92% (right column). Statistical errors are indicated by the error bars on the points. The systematic error on the normalization is given as the dashed line bracketing zero. The systematic error due to the v_2 uncertainty is the solid histogram around the data points. Not shown is a systematic error of 10% due to the single hadron efficiency and 5% from the combinatoric contribution under the π^0 peak.

collisions for the two trigger ranges considered here, 5-7 GeV/c and 7-20 GeV/c. The S/B is 3.6 for the 5-7 GeV/c and 8.6 for 7-20 GeV/c triggers. To measure the effect on the correlations due to the fake π^0 triggers, correlations with di-photon triggers in mass ranges below and above the π^0 peak are measured. The correlations from these combinatoric photon triggers within the π^0 mass window are then extrapolated. In this analysis since the S/B is sufficiently large the effect of the background correlations is 5% nearly independent of $\Delta\phi$ and as such we assign a 5% systematic error on the correlations.

Once the physical correlations are measured, the interest is in the correlations due to jets. In $A + A$ collisions the elliptic flow results in a physical two-particle correlation. This is removed by assuming that the correlations can be decomposed

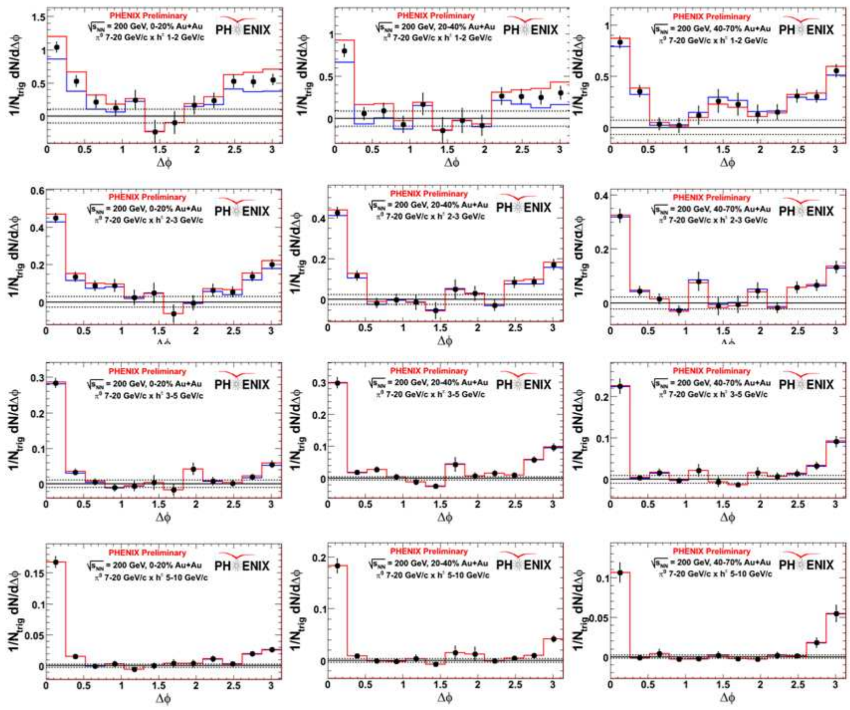

Fig. 3. Correlations between π^0 triggers from 7-20 GeV/c and associated hadrons from 1-2 GeV/c (upper row), 2-3 GeV/c (second row), 3-5 GeV/c (third row), and 5-10 GeV/c (lower row) in Au+Au collisions in 0-20% central (left column), 20-40% central (middle column), and 40-92% (right column). Statistical errors are indicated by the error bars on the points. The systematic error on the normalization is given as the dashed line bracketing zero. The systematic error due to the v_2 uncertainty is the solid histogram around the data points. Not shown is a systematic error of 10% due to the single hadron efficiency and 5% from the combinatoric contribution under the π^0 peak.

into two sources [9].

$$\frac{1}{N_{trig}}\frac{dN}{d\Delta\phi} = B\left(1 + 2v_2^{trig}v_2^{assoc}\cos\left(2\Delta\phi\right)\right) + \mathcal{J}\left(\Delta\phi\right) \tag{1}$$

The v_2 of the trigger and associated particles are measured independently from an analysis of the single π^0 and charged hadrons with respect to the reaction plane [10]. The background level B must be determined in order to subtract the elliptic flow contribution. This is done by the Zero Yield At Minimum (ZYAM) method [9]. In the end the jet correlations have errors due to background determination from ZYAM and the uncertainties in the measured v_2 values.

3. Results and Discussion

The resulting jet correlations between π^0 triggers and associated hadrons are shown in Fig. 2 and Fig. 3 for π^0 triggers from 5-7 GeV/c and 7-20 GeV/c respectively. The associated hadron p_T varies top to bottom in the bins 1-2 GeV/c, 2-3 GeV/c, 3-5 GeV/c and 5-10 GeV/c, respectively. The centrality of the collisions varies left to right in bins of 0-20%, 20-40%, and 40-92%, respectively. The dashed lines on the correlations around the zero line indicate the uncertainty in the background level from the ZYAM procedure. The solid lines around the points indicate the error on the v_2. All errors are 1σ.

From these jet correlations no obvious lobed structure is observed as in lower trigger p_T correlations. A statistically significant away-side distribution is observed at all p_T and centrality. What is not clear from these data alone are any systematic trends in centrality, associated p_T , or trigger p_T for yield at $\Delta\phi$ ∼2 rad.

In the future it will be necessary to compare to directly to the correlations in p+p and to quantify whatever yield exists in Au+Au compared to p+p to search for the existence of conical structure at these p_T. Further, it will be important to extend the π^0 trigger p_T reach down to 2-5 GeV/c where the strong modifications are seen in unidentified hadron triggered correlations.

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